CLAIMS

1. A system for measuring the flight of a projectile, comprising:

a projectile comprising an exterior surface and a set of orientation identifiers distributed over the exterior surface, such that, for every orientation of the projectile, there exists, from any fixed perspective, a unique viewable configuration of a sub-set of the identifiers;

means for capturing a first image of the surface of the projectile at a first time, the first image including a first configuration of a first sub-set of the orientation identifiers;

means for determining the orientation of the projectile from the first configuration;

means for capturing a second image of the surface of the projectile at a second time, the second image including a second configuration of a second sub-set of the orientation identifiers;

means for determining the orientation of the projectile from the second configuration; and

means for determining the rotational velocity of the projectile in flight from its orientation at the first time and its orientation at the second time.

2. A system as claimed in claim 1, further comprising means for determining the translation velocity of the projectile from the first and second images.

3. A system as claimed in claim 1 or 2, wherein the means for capturing a first image and means for capturing a second image is a digital camera.

4. A system as claimed in any one of claims 1 to 3, comprising a processor for providing means for determining the orientation of the projectile from a configuration of a sub-set of the orientation identifiers.

5. A system as claimed in any one of claims 1 to 4, further comprising a flash gun arranged to fire at the first time and the second time.

6. A system as claimed in claim 5, further comprising a projectile launch detector for controlling the flash gun.

7. A computer program comprising computer program instructions that when loaded into a computer provide means for determining the orientation of a projectile from a given configuration of a sub-set of the orientation identifiers, wherein the projectile comprises an exterior surface and a set of orientation identifiers distributed over the exterior surface, such that, for every orientation of the projectile, there exists, from any fixed perspective, a unique viewable configuration of a sub-set of the identifiers.

8. A record medium embodying the computer program as claimed in claim 7.

9. A method of determining the placement of orientation identifiers on the exterior surface of a projectile, comprising:

a) defining an initial set of identifiers;

b) distributing the set of identifiers over the surface of a simulated projectile;

c) testing the existence of unique configurations of viewable identifiers for different orientations of the simulated projectile;

d) adapting the distribution of identifiers, if the test fails, otherwise, simplifying the set of identifiers and returning to step b) ; and

e) terminating the method.

10. A method as claimed in claim 9, wherein the projectile is simulated using a polygonal mesh that approximates the surface of the projectile.

11. A method as claimed in claim 9 or 10, wherein the set of identifiers comprises a plurality of spots.

12. A method as claimed in claim 9, 10 or 11, wherein the set of identifiers comprises less than 55 identifiers.

13. A method as claimed in any one of claims 9 to 12, wherein the identifiers are randomly distributed.

14. A method as claimed in any one of claims 9 to 13, wherein the step of testing comprises testing the existence of a unique configuration of a sub-set of the viewable identifiers for each orientation of the simulated projectile.

15. A method as claimed in claim 14, wherein the sub-set lies within a region of confidence.

16. A method as claimed in any one of claims 9 to 15, wherein the step of testing comprises running the following process a specified number of times:
(i) determining a random orientation;
(ii) determining, for that orientation, the configuration of a sub-set of viewable identifiers;
(iii)calculating a measure of the configuration of the sub-set of viewable identifiers;
(iv) comparing the calculated measure with measures of the configurations of similar sub-sets of viewable identifiers for different orientations
(v) return to (i),
wherein the test fails if there are positive comparisons.

17. A method as claimed in claim 16, wherein a measure of a configuration comprises a set of chordal distances between one identifier and other identifiers.

18. A method as claimed in any one of claims 9 to 17, wherein the step of adapting the distribution of identifiers comprises the random movement of one identifier.

19. A method as claimed in any one of claims 9 to 18, wherein the step of simplifying the set of identifiers comprises reducing the number of identifiers.

20. A method as claimed in claim 9 or 10, wherein the set of identifiers comprises the colours of tessellating panels of the projectile.

21. A method as claimed in claim 20, wherein the number of colours used is less than 10.

22. A method as claimed in claim 20, wherein number of colours used is 5

23. A method as claimed in any one of claims 20 to 22, wherein the step of distributing the set of identifiers comprises randomly distributing the colours over the panels.

24. A method as claimed in any one of claims 20 to 23, wherein the configuration of viewable identifiers comprises the colour of a central panel and the colours of its adjacent panels.

25. A method as claimed in claim 24, wherein test fails if adjacent panels have the same colour.

26. A method as claimed in any one of claims 20 to 25, wherein test fails if there is the same configuration of viewable identifiers for different orientations of the simulated projectile.

27. A method as claimed in any one of claims 20 to 26, wherein the step of adapting the distribution of identifiers comprises the random change of the colour of a panel.

28. A method as claimed in any one of claims 20 to 37, wherein the step of simplifying the set of identifiers comprises a reduction in the number of colours used to colour the tessellating panels of the projectile.

29. A method as claimed in any one of claims 9 to 28, wherein the step of terminating occurs after a predetermined number of iterations or a predetermined run-time

30. A computer implemented method as claimed in any one of claims 9 to 29.

31. A computer program for performing the method of any one of claims 9 to 29.

32. A projectile having an exterior surface and comprising a placement of orientation identifiers on its exterior surface determined in accordance with the method of any one of claims 9 to 29.

33. A projectile comprising an exterior surface and a minimal set of orientation identifiers distributed over the exterior surface, such that, for every orientation of the projectile, there exists, from any fixed perspective, a unique viewable configuration of a sub-set of the identifiers.

34. A projectile as claimed in claim 33 comprising a plurality of coloured tessellating panels.

35. A projectile as claimed in claim 34, comprising a minimal number of different colours.

36. A projectile as claimed in claim 34, having a shape substantially that of a 32-sided truncated icosahedra and having panels coloured using five different colours.

37. A projectile having orientation identifiers placed on its exterior surface as described in the table of page 14.

38. A soccer ball having tessellating panels coloured in accordance with the table of page 21.

39. A method of marking a projectile such that any view of the surface of the projectile displays a pattern of projected markings that is unique to that view and to any rotation of that view; the method comprising the following steps:

(a) approximating the surface of said projectile by a polygonal mesh;

(b) choosing an initial number of markings as a trial number;

(c) distributing said number of markings at random about said polygonal mesh;

(d) applying an appropriate algorithm to remove from said distribution of markings any non-uniqueness of view within the region of confidence, and any perceived rotational symmetry in any one view;

(e) reducing said number of markings, and repeating steps (c) and (d) above; and

(f) repeating this process until no mathematical solution is obtainable;

the number and distribution of markings applicable to the projectile being determined by the solutions thereby obtained.

40. The method of Claim 39 wherein the least-number solution comprises a number of markings less than 55.

41. The method of Claim 38 wherein said features comprise a plurality of regions, each said region being identified by one of a multiplicity of colours (as herein defined).

42. The method of Claim 41 wherein step (d) of Claim 39 additionally removes from said distribution of markings any adjacent regions being identified by the same colour (as herein defined).

43. The method of Claim 41 or 42 wherein the number of colours is less than 10.

44. The method of Claim 41 or 42 wherein the number of colours is 5.

45. A method of marking a projectile substantially as described herein, with reference to and as illustrated in the accompanying drawings

46. A projectile marked with a pattern coincident or substantially coincident with one obtained according to any of the above claims.

47. A system for monitoring movement imparted to a projectile, marked according to any of the above methods, comprising:

launch detection means to detect the moment of launch of said projectile;

image acquisition means to acquire images of said projectile, in flight;

control means to activate said image acquisition means in reaction to the moment of launch of said projectile;

processing means capable of determining the velocity and spin of said projectile by comparison of a plurality of images so acquired, and adapted to do so by virtue of being cognisant of the essentials of the marking method embodied in said projectile; and

display means to display the velocity and spin to a user, in use.